Using Animal-Borne Cameras to Quantify Prey Field, Habitat Characteristics and Foraging Success in a Marine Top Predator

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LONG-TERM GOALS

To understand the factors which influence population dynamics in marine mammals, and the potential risks anthropogenic activities pose, knowledge of their habitat use and the environmental factors determining foraging success is required. While over the last decade great advances have been made in this area for pelagic foraging species, such information is largely lacking for benthic foraging marine mammals. Therefore, the long term goals of this project are to determine in a model species (the Australian fur seal) the key ecological characteristics of their benthic foraging habitat, the profitability (prey captured *versus* effort) of various habitats and the spatial distribution of critical habitat. The techniques and principles developed in this project will be applicable for a variety of benthic foraging seal species world-wide and will contribute to our understanding of the role of top predators in shaping marine communities.

OBJECTIVES

The specific aims of the study are to:

1) quantify the prey fields encountered by adult female Australian fur seals in various habitats using video footage recorded on the seals;
2) determine seal movements at the fine-scale appropriate to prey encounters using GPS loggers and 3-axis accelerometers;
3) quantify net energy gain while foraging in different habitats; and
4) establish the habitat characteristics and individual factors that influence these parameters.

APPROACH

The aims of this study will be achieved through a conceptually simple, yet highly effective, methodological approach. Animal-borne video recording equipment will be combined with high resolution tracking to characterise and map the benthic habitats in which Australian fur seals forage and to determine the relative profitability of these habitats as measured by foraging success (prey consumption/energy expended).

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The study will be conducted on Kanowna Island, northern Bass Strait, which hosts a large breeding colony with an annual production of *ca*3000 pups. Individual adult females suckling pups will be selected at random, captured and instrumented with a digital video recorder data logger (Crittercam® V5.7, National Geographic Society, Washington, USA) encased in a water-proof aluminium housing (5 cm diameter, 25 cm length). The device will be glued to the dorsal fur along the mid-line posterior to the scapula using quick-setting epoxy (Fig. 1). The Crittercam is designed to record high resolution, wide angle, video footage in low ambient daytime light levels encountered at depths of up to 100 m and on-board red LED beams provide sufficient light to record video at night. To enable complete foraging trips (6-10 days) to be sub-sampled, the Crittercam will record video data on a duty-cycle of 1 h on:3 h off. In addition to storing video footage, data from on-board sensors (depth ± 0.5 m, 3-axis accelerometer ± 0.06 G, compass ± 1º) is recorded enabling accurate three-dimensional dive profiles to be reconstructed (Simpkins et al. 2001). From such profiles, linear distances travelled can be measured enabling the size of features along the sea floor to be calculated. As well as the Crittercam, a small VHF transmitter and a FastLoc GPS® data logger will also be attached to the animal to assist in relocating it at the colony for recapture and for recording at-sea movements, respectively. In total, all devices attached to the seals will represent <2% body mass and <1% cross-sectional surface area and, thus, negligible additional hydrodynamic drag (Wilson et al. 1986).

Fig.1: Adult female Australian fur seal (Arctocephalus pusillus doriferus) on Kanowna Island, northern Bass Strait, instrumented with a Crittercam® video data recorder, VHF transmitter and Fastloc GPS® logger.

To investigate potential individual factors influencing foraging behaviour, age and body size will be determined in the instrumented females. Once morphometric measurements have been collected and the animal has recovered from the anaesthesia, it will be released and left to forage for a single trip to sea before being recaptured and the devices removed by cutting the fur beneath them. Data from the loggers will be downloaded in the field onto portable computers and their batteries recharged so that they can be redeployed on additional animals.

In the laboratory, the at-sea movements of individuals instrumented with a Crittercam will be mapped using the data downloaded from the FastLoc GPS® logger concurrently deployed on them. The high accuracy of locations (± 10 m) and fast sampling interval (5 min) of these loggers, coupled with the 3-dimensional reconstruction of dive profiles using the accelerometer data, will enable foraging routes to be determined with very high resolution. The video recordings will then be analysed for the type, number and density (based on the length of foraging tracks) of prey encountered. The benthic habitats visited by seals will be categorised using the towed-video classification program developed for the Victorian Marine Habitat Mapping Program (Ierodiaconou et al. 2007). These analyses will enable statistical comparisons of prey fields, and capture rates, between various benthic habitat types.

WORK COMPLETED

Deployments of Crittercams in conjunction with dive behaviour recorders and GPS data loggers continued during the winter (May-September) of 2012. A total of 11 deployments were conducted. However, equipment failure severely impacted data collection and prevented additional deployments. Three cameras were deployed twice but malfunctioned each time and no video data were obtained. For ethical reasons, these were decommissioned for the remainder of field season until they could be examined by the manufacturer. Three more cameras were damaged from leakage during deployment, with only one yielding data. The other two deployments were successful and all three video data sets are currently being processed.

Analysis of data collected in previous years of the project has progressed, with the classification of benthic habitats visited and identification of prey species encountered completed for 18 individuals and >1400 dives. This information is providing insights into the relationships between habitat type and prey availability. In conjunction with GPS locations, these data were then used to develop predictive distributions of the preferred foraging areas for female Australian fur seals, both at the individual level and population level. MAXENT models were used to model geographic distributions using environmental variables (bathymetry, slope derivative, distance to anthropogenic infra-structure, distance to coasts, benthic substrate and community structure) and dive presence data. MAXENT is a general-purpose, machine-learning method with a simple and precise mathematical formulation, and it has a number of aspects that make it well-suited for species distribution modelling.

Estimation of foraging effort (using flipper stroke as a measure of cost of transport) is currently in progress. This is a time consuming process whereby the individual flipper strokes observed in the video sequences must be counted and tabulated. Once obtained, this information will be compared to the prey capture data (number and type) to investigate relationships between foraging success, efficiency, prey type and habitat.

RESULTS

The majority of prey consumed by individuals instrumented with video data loggers were cryptic benthic species such as gurnard fish (Family Triglidae) and octopus (*Octopus maorum*, *O. pallidus*), with schooling fish like Jack Mackeral (*Trachurus declivis*) and demersal rays comprising a smaller proportion of identifiable prey (Table 1). Consistent with previous preliminary analyses, there were clear individual differences in the prey types encountered/consumed with some seals consistently targetting particular types of prey. While some individuals consistently consumed smaller prey such as gurnards, others regularly targetted larger prey such as octopus and rays. Individuals targetting smaller

prey were generally consuming several items per dive whereas individuals targetting large-bodied prey such as octopus consumed a single item per dive, travelling to the surface to process it.

The bethos in the regions frequented by individuals was comprised overwhelmingly of sandy substrate (Table 2). Due to low the clarity of the video data obtained during night-time foraging, a small proportion of substrate encountered could not be classified. Rocky reefs comprised <2% of substrate where seals foraged. Rocky reefs provide structural complexity which has been observed to influence associated fish and invertebrate communities in near-shore marine environments. The low incidence of such habitats in the video records suggests their presence within the foraging range of Australian fur seals from the study colony is limited. This further highlights the potential beneficial impact of anthropogenic sea floor structures in increasing prey diversity and abundance for top-order predators within Bass Strait.

Table 1: Proportion of various prey types encountered by female Australian fur seals instrumented with animal-borne video data loggers

Prey type	Proportion of encounters (%)
Gurnard	42
Octopus	33
Jack Mackeral	6
Rays/skates	5
Squid	3
Miscellaneous/Unidentified	11

Table 2: Proportion of dive time spent on the sea floor of different substrates by female Australian fur seals instrumented with animal-borne video data loggers.

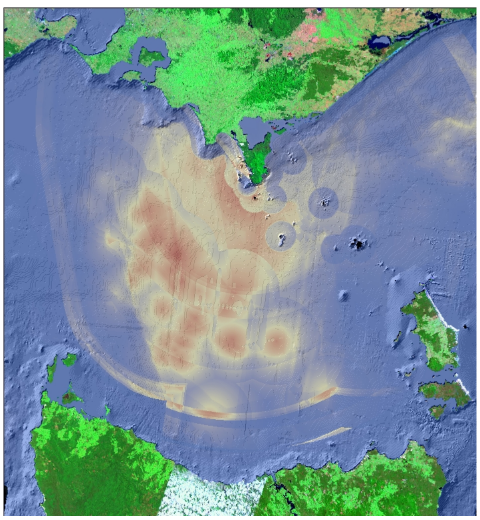
Substrate	Proportion of time on sea floor (%)
Sand	89
Gravel/sand	3
Rock	2
Shell/sand	2
Unknown	4

On all substrate types, sponges were the predominant invertebrate. The majority of prey encounters and captures (>60%) occurred in areas where the benthic invertebrate community was classified as sparse/medium sparse, mostly on sandy substrate but also on rocky reefs. MAXENT models developed using environmental parameters (e.g. bathymetry, distance to geopgraphic and

anthropegenic features) and the classification of benthic communities in the animal-borne video data provided a predictive habitat suitability model for the Kanowna Island Australian fur seal colony (Fig. 1a). The regions identified by the model as preferred habitat are consistent with previous tracking data from a large number of individuals (Fig.1b). Significantly, this confirms the effectiveness of using animal-borne video data to derive predictive habitat suitability models in this species.

IMPACT/APPLICATIONS

The overall aim of the proposed research is to determine the factors which influence spatial and temporal foraging success in an important marine predator. In particular, by employing new biologging and telemetry technology we will be able to quantify three particularly elusive aspects of marine mammal foraging ecology: the prey field, foraging success and foraging costs. The project focuses on the Australian fur seal where this information is vital for predicting how the most



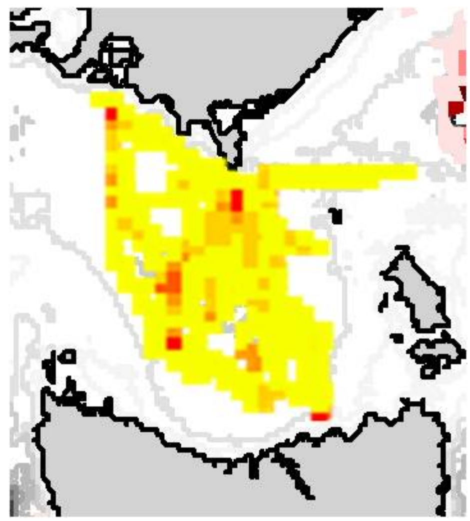


Fig. 1: (a) Predictive habitat suitability model (MAXENT) derived for 18 female Australian fur seals instrumented with animal-borne video data loggers (2010-12); habitat use by 52 female Australian fur seals tracked using satellite transmitters (2003-05; Arnould and Kirkwood 2008) and GPS (2006-09, Arnould et al. unpubl. data).

significant marine predator biomass in south-eastern Australia, and its impact on the marine ecosystem, will respond to environmental variability. The project, however, has broader international significance in that it will contribute to our understanding of the role of top predators in shaping marine communities, which is of particular importance given anticipated global climate change and the world-wide ever-increasing human exploitation of marine resources.

This study has additional global significance as the underlying principals determining foraging success will be applicable for a variety of benthic foraging seal species whose populations are currently under threat and where the impacts of bottom/demersal trawls by commercial fisheries on their prey field are unknown. Furthermore, an important and novel spin-off from this research will be improved mapping of sea-floor characteristics in many parts of the world, for a range of uses (e.g. environmental assessment, ecosystem monitoring), on a scale not feasible using conventional methods (i.e. hydrographic surveys and benthic trawl sampling).

RELATED PROJECTS

There are currently no projects directly related to the one being reported here.

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